The Cosmology of Dante.

By Dr. J. L. E. Dreyer.

The study of the cosmological ideas set forth in Dante's great poem is of considerable interest, not only because it helps us to understand many parts of the poem which otherwise might appear obscure, but also because Dante is a faithful interpreter of the opinions about the construction of the universe which were prevalent in his day. In this respect he is unique among poets. In the present article we shall trace the origin and gradual development of the system of the world adopted by Dante, without entering on minute interpretations of particular passages.

The principal feature of this system is the arrangement of the universe in a series of concentric spheres with the earth in the centre (Fig. 1). This is a very old idea, originating in the most striking of all celestial phenomena, the rotation of the heavens in twenty-four hours from east to west. Eudoxus (about 370 B.C.) was the first to design a complete system of concentric spheres, arranged so as to account for this rotation of the heavens as well as for the principal irregularities in the motions of sun, moon, and planets in the opposite direction. Though Eudoxus was a great mathematician, his system of spheres could account only partially for the observed phenomena, probably because it was founded on an utterly insufficient number of observations of these phenomena. The system was much improved by Kalippus, and, what was of more importance, it was accepted by Aristotle. To him the spheres were not merely mathematical conceptions, but physically existing bodies, kept in motion by the soul of each. Notwithstanding his great authority, however, this system was rejected by the astronomers of Alexandria, chiefly because it suffered from an incurable defect, that of assuming every planet to be always at the same distance from the earth. That this is not the case is clearly shown by the variable brightness of the planets, most strikingly seen in the case of Venus and Mars.

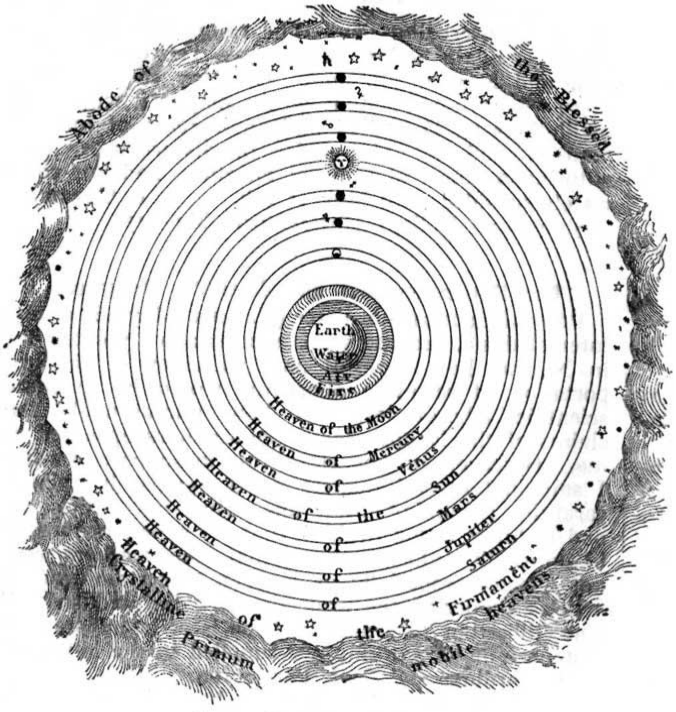

Fig. 1.—Dante's cosmical system.

The increased number of apparent irregularities in the planetary motions revealed by steadily pursued observations led to the development of a system of the world which finally became known as the Ptolemaic system, because the last touches were put to it by Claudius Ptolemy in the second century A.D. It assumed a planet to move on a circle, the epicycle, the centre of which moved on a larger circle, the eccentric, near the centre of which the earth was situated. Additional refinements were added to account for observed minor irregularities. But all this, though very satisfactory to mathematicians, was not to the taste of many people, who could not accept all these circles as realities, but demanded some sort of a system of spheres, not necessarily concentric. To satisfy this demand it was suggested that we might for the epicycle substitute a small sphere, to the surface of which a planet was attached, while the sphere fitted in and moved between the surfaces of two concentric spheres, near the common centre of which the earth was placed. Ptolemy, who wrote a valuable text-book on astronomy (the "Syntaxis," generally known by the Arabic name "Almagest"), wrote also, for the weaker brethren, another, called "The Second Book of Phenomena," in which a complicated system of spheres is described. But this was never a success, and the Greek original is lost, so that the book was quite unknown to modern European readers until 1907, when a German translation from an Arabic version was at last published.

Among the Arabs we find an attempt to adopt material spheres in the cosmical system of the "Brethren of Purity," a semi-religious society which arose at Basra near the end of the tenth century. They taught that there are nine spheres of different thicknesses, fitting inside each other "like the skins of an onion." The ninth sphere is the prime mover, and turns in twenty-four hours. The eighth sphere is that to which the fixed stars are attached; it revolves in a very slightly longer period, lagging behind to the amount of one degree in a hundred years. This is supposed to account for the precession of the equinoxes. Saturn (the seventh sphere) lags more, and the motion becomes slower as we descend through the spheres, until we reach the first or slowest sphere, that of the moon, which takes about fifty minutes more than twenty-four hours to make a complete revolution. In other words, all celestial motions take place in the same direction, from east to west. This is a very old idea, several times alluded to by Plato; but the denial of the independent eastward movement of the planets could not commend itself to any Greek astronomer who realised that the planets moved in orbits considerably inclined to the direction of the daily rotation. This was also the case among the Arabs, and no prominent advocate of a system of spheres appeared among them until the rise of the Aristotelian philosophy in Spain in the twelfth century revived the belief in spheres. Al Betrugi (Alpetragius) wrote a book on the subject, in which he also let all the motions be from east to west. But though he made some attempt to account for the most conspicuous irregularities of the planetary motions, his system is not to be compared with the Ptolemaic system as regards completeness, and it could be accepted only by people who were content merely with the rough outline of a system.

Early in the thirteenth century Arabian books on philosophy and science began to be known north of the Pyrenees, and along with them came the writings of Aristotle, translated long before from Greek into Arabic, and now from Arabic into Latin. As Aristotle, who very soon was accepted as an infallible guide, had adopted a system of spheres, one outside the other, it was very difficult for his Christian admirers to do anything else. During the whole of the thirteenth century there was a running fight between the adherents of Aristotle (or Alpetragius) and those who realised that no system of concentric spheres could ever account for the observed phenomena so completely as the Ptolemaic system of epicycles and eccentrics did. By the year 1300 the fight was in France fairly well decided in favour of the followers of Ptolemy. But in Italy the study of science had scarcely made any progress; Ptolemy's great work (though translated into Latin as early as 1175 by Gherardo of Cremona) was quite unknown, and only an extremely elementary text-book by Al Fargani was used in the universities.

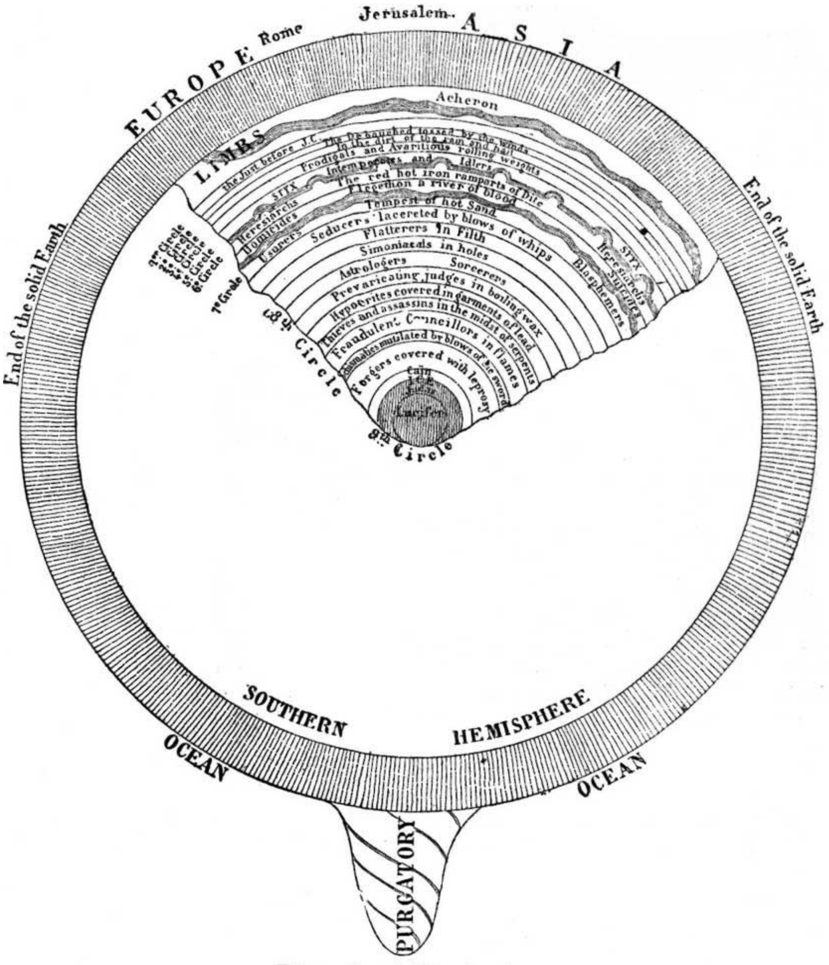
Jerusalem
Rome
EUROPE
ASIA
End of the solid Earth
End of the solid Earth
Acheron
LIMBS
the Just before J.C.
The Debauched tossed by the winds
In the dirt of the rain and hail
Prodigals and Avaritious rolling weights
Intemperates and Idlers
STYX
The red hot iron ramparts of Dite
Flegethon a river of blood
Heresiarchs
Homicides
Usurers
Tempest of hot Sand
Seducers lacereted by blows of whips
Flatterers in Filth
Simoniacals in holes
Astrologers
Sorcerers
Prevaricating judges in boiling wax
Hypocrites covered in garments of lead
Thieves and assassins in the midst of serpents
Fraudulent Councillors in flames
Schismatics mutilated by blows of the sword
Forgers covered with leprosy
Cain
ICE
Judas
Lucifer
STYX
Heresiarchs
Suicides
Blasphemers
2nd Circle
3rd Circle
4th Circle
5th Circle
6th Circle
7th Circle
8th Circle
9th Circle
SOUTHERN
HEMISPHERE
OCEAN
OCEAN
PURGATORY

Fig. 2. Dante's infernal regions.

It was therefore natural enough that Dante should be persuaded of the truth of the doctrine of concentric spheres. Besides, this readily lent itself to poetic treatment, which a complicated set of circles could never do. There is no trace, either in the "Commedia" or in the philosophical treatise the "Convivio," of his having known the "Syntaxis" of Ptolemy. The chief source of his astronomical knowledge is the little text-book of Al Fargani, which he frequently quotes, and from which he occasionally borrows whole passages. In the "Convivio" he repeatedly makes use of the writings of the great scholastic, Albertus Magnus. In contrast with several Italian writers on astronomy even long after his time, who often displayed great ignorance, Dante shows himself well acquainted with the general phenomena of the heavens. Thus he describes correctly the apparent motions of the stars as seen from the poles of the earth or from the equator; he often indicates the time of year by mentioning the zodiacal sign occupied by the sun; he even gives a fairly closely correct value of the length of the year.

In the centre of the universe is the earth, which is a sphere. These two facts were not disputed by anybody. Hell is a conical opening reaching to the centre of the earth, where the devil dwells at the apex of the cone (Fig. 2). Among theologians this was generally accepted as the proper place for him. Even three hundred years later, when the motion or non-motion of the earth was the burning question of the day, the idea appeared very shocking to many that a body having the devil in the middle could be supposed to travel among the heavenly bodies, which were moved by angels. Purgatory is a large conical hill, rising out of the vast ocean at a point diametrically opposite to Jerusalem, the navel of the dry land. The heavenly spheres, ten in number, surround the earth, and they are repeatedly alluded to as being solid. In each of the first seven spheres spirits, though they have not their permanent abode there, appear to Dante in order to illustrate the gradually increasing glory which they have been found worthy to enjoy, and to indicate their former earthly characters, which had been chiefly influenced by one of the seven planets. The shadow of the earth reaches as far as the third sphere, and the spirits seen in the spheres of the moon, Mercury, and Venus have the lowest degree of bliss in the Empyrean.

The tenth sphere, the Empyrean, is the dwelling of the Deity. It is motionless, because all motion implies change and a desire for something better. The ninth, or crystalline, sphere is the prime mover, endowed with circular motion which expresses its praise of the Creator, and by its almost incomprehensible speed it shows the desire of each part of it to be joined to the Empyrean. The eighth sphere is that of the fixed stars; it has a very slow eastward motion of its own of one degree in a hundred years (precession), and transmits the daily rotation received from the ninth sphere to all the lower spheres. Dante seems, however, to have been somewhat uncertain about the source of rotation: in one place in the "Convivio" (ii., 15) he attributes both rotation and precession to the eighth sphere, though he immediately afterwards returns to his usual theory; and in another place ("Convivio," ii., 6). when speaking of Venus, he says that "whether the daily movement comes from some intelligence or from the onrush of the prime mover, God knows, for it appears to me presumptuous to decide." But these passages seem only to indicate some momentary hesitation between the conflicting statements of his sources. In the same way he is doubtful about the nature of the Milky Way, whether it is composed of stars or of vapour. He is particularly disturbed by the difference between the "new" translation of Aristotle (by Thomas Aquinas, from Greek) and the "old" one (by Michael Scot, from Arabic), but he inclines to the statement of the latter, that it is a multitude of stars.

The nine revolving spheres are moved by the three triads of angelic intelligences, the Seraphim as the highest in rank directing the ninth sphere, while the angels govern the lowest sphere, that of the moon. The planets were supposed to move in the plane of the ecliptic. There is no mention of the motion being eccentric, though Dante must have seen the account of the eccentric circles given in Al Fargani's book. But these were inconvenient things to believers in a system of spheres, and were better ignored. On the other hand, there are several allusions to epicycles; thus it is said in a paragraph in the "Convivio" (ii., 4) about Venus that on the circle of its sphere there is a small sphere which astronomers call an epicycle, "and though we say that there are ten spheres, this number does not comprise them all."

The last and lowest of the ten spheres is that of the moon. While the motion of Saturn is the swiftest, because this is most divine motion, that of the moon is the slowest ("Paradiso," iii., 51). The revolutions of all the nine spheres are therefore from east to west as supposed by some of the early Greek philosophers and by all the Arabian believers in spheres. As to the nature of the moon, and particularly of the surface-markings, Dante, in the "Convivio" (ii., 14), adopts a theory, due to Averroes, according to which the spots are caused by the rarity of some parts of the moon's body which do not reflect the sun's rays well. But in the "Paradiso" (ii. and xxii.) this is objected to, and the spots, which Dante, looking from above, sees only on the side of the moon nearest the earth, are said to be due to the light differing in various places under the influence of different angelic guides.

From the highest heavens to the lowest depths of the earth we find in Dante a faithful guide to the scientific ideas as well as to many popular prejudices of his time. Though the theory of spheres was during his lifetime defeated in France, an Italian may well be pardoned for not recognising this, particularly when we remember that even 200 years later two separate attempts were made in Italy to set up scientific theories of concentric spheres. To the student of the history of science it is a never-failing source of pleasure to find medieval cosmology so beautifully illuminated in the writings of the great Florentine poet.

The Natural History of Cultivated Plants.[1]

CLASSICAL plant-names like Μηδικὴ πόα or *spina Arabica*, designed to indicate origin, do not always fulfil their object. Pliny's specific reference to *milium intra hos decem annos ex India in Italiam invectum* has not obviated debate as to the home and the identity of his plant. Many notices of ancient crops connote only local cultivation.

Renaissance naturalists connected their culti-

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[1] "Sino-iranica. Chinese Contributions to the History of Civilization in Ancient Iran, with special reference to the History of Cultivated Plants and Products." By Berthold Laufer. (Field Museum of Natural History Publication 201: Anthropological Series, vol. xv., No. 3.) Pp. iv+445. (Chicago, 1919.)